Phytophthora Root Rot of Port-Orford-Cedar

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Root rot of Port-Orford-cedar, *Chamaecyparis lawsoniana*, is caused by the soil fungus, *Phytophthora lateralis*. This fungus infects succulent feeding roots and spreads in the inner bark to quickly kill the tree. Nursery stock, ornamental, windbreak, roadside, and timber trees alike are liable to infection. Largest infected trees die within 2 to 4 years, the smallest within a few weeks. The rate of disease development and appearance of infected trees may differ with environment, but death is always certain. The chance that a tree will be attacked depends on the probability of its being exposed to the fungus: Remote trees on high ground may escape infection indefinitely. Other species of *Chamaecyparis* appear less susceptible than Port-Orford-cedar, and trees of other genera accompanying cedar in the coastal forest are completely unaffected.

History and Distribution

The origin of this *Phytophthora* is unknown, but the complete susceptibility of Port-Orford-cedar suggests that the fungus evolved outside the native range of this tree, possibly in Europe or Asia. The disease was first reported near Seattle in 1923 in nursery stock imported from France. Asiatic species of *Chamaecyparis* have a degree of resistance that suggests a long association between host and pathogen; however, the disease is not known today in either Europe or Asia.

Phytophthora lateralis was discovered and named in 1942 during studies of the disease among ornamentals in the Willamette Valley. Losses of cedars in nurseries and home plantings became so severe in valleys of western Oregon that within a decade nurserymen largely abandoned production. This happened later in Washington and British Columbia.

In 1952, the disease was found in the heart of the native range of Port-Orford-cedar at three locations in southwestern Oregon. Here, young cedar abounds on wild and cutover lands and is commonly grown as an ornamental. By 1954, mortality was conspicuous in the area's cities, along major roads, around construction

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sites, or wherever earth was moved. Colored aerial photographs taken in 1956 showed a network of dying trees along water courses, around lakes and sloughs, along rural roads, livestock trails, and around farmsteads. The disease has now spread in the lowlands to the limits of the cedar range. Its spread into the mountain forests has been slower but is accelerating. One may easily be impressed that the disease is declining in the lowlands because the more conspicuous trees have died and present damage is farther from the roads and less readily seen.

In areas with mild, moist climates, Port-Orford-cedar may be attacked by *Phytophthora cinnamomi*. Symptoms are similar and the two diseases may overlap near the southern limits of *P. lateralis*, as they do among ornamentals in irrigated nurseries. Root rot of Port-Orford-cedars introduced into Southern United States and Europe is due to *P. cinnamomi*.

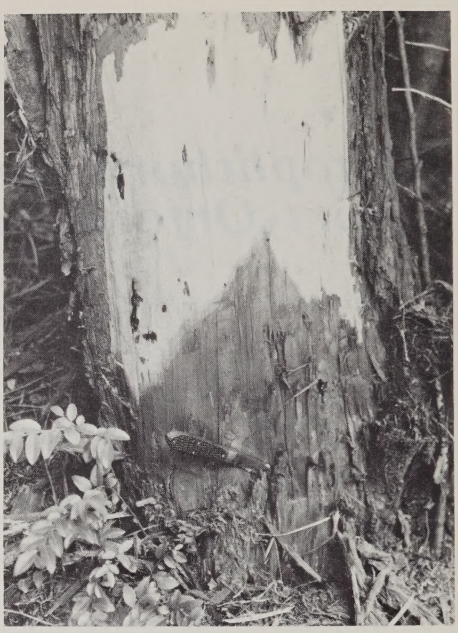

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Figure 1. — Pole-sized Port-Orford-cedar with the outer bark removed to expose the distinctively discolored zone of inner bark which accompanies invasion by *Phytophthora lateralis* from the roots. (Photo, courtesy Oregon State University, Corvallis.)

Description

Rootlets infected with *P. lateralis* first appear watersoaked and then darken. Inner bark and cambium discolor progressively with advance of the fungus as far as the root collar (fig. 1). Tissues invaded by the fungus become discolored a deep cinnamon brown that contrasts strongly with the rich cream color of healthy inner bark. Spread of the fungus up the trunk as the crown dies is limited to a distance of about twice the stem diameter.

Where healthy trees are present for comparison, foliage of infected trees appears slightly lighter in color and on warm spring days wilts slightly. Later, the foliage becomes slightly withered, turns various shades of yellow, then bronze, and finally light brown. Foliar discoloration occurs simultaneously throughout the crown. The final browning develops concurrently with drying and darkening of the inner bark. Infected trees are often attacked by bark beetles which speed death and modify foliage discoloration toward a deeper reddish brown.

The Fungus and Disease Spread

In laboratory culture, the fungus grows as a tangle of filaments smaller than cotton fibers. Minute, lemon-shaped sacs containing swimming spores form at the filament tips, and thick-walled, spherical, resting spores develop along the sides of the filaments. We assume that when the soil is saturated, the swimming spores burst forth and move with the surface water. When the spore-bearing water percolates into the soil, new infections of root tips

occur. Resting spores are believed to spread the fungus in mud and soil as they are moved about.

From existing knowledge, it is evident that major spread of the disease occurs through earth movement in construction, in road maintenance and use, and in logging operations. Surface water is also important in moving the fungus, as is movement of infested soil in the nursery trade. Movement of the fungus in soil on feet of cattle has been particularly important in the cedar region where livestock production is extensive. Possibly the fungus is moved on the feet of game, particularly elk. Poorly understood, but important, is spread within and between root systems, counter to the direction of movement of soil water.

Damage

The economics of losses from this disease have not been analyzed. However, the ornamental nursery industry has suffered large losses in unmerchantable stock, reduced productivity of land, and costs of replacing dead trees for customers. Less tangible have been loss of markets, costs of conversion to other crops, and, in the native region, a general reduction of environmental quality caused by death of so many trees. Residential owners have experienced considerable loss from depreciation of property values and from cost of replacing landscape trees which have died.

Dollar losses to commercial forestry have been small to date. Twenty years after introduction of the disease, greatest loss has resulted from death of thousands of young-growth trees at the lower size limits of merchantability. Most of these unsalvaged trees are in farm wood lots (fig. 2) and surburban residential areas.

All commercial Port-Orford-cedar is threatened. Since the value of large cedar logs is very high, loss of a single tree regardless of age seems economically significant.

In forest harvest by staggered settings, old-growth Port-Orford-cedar in the Coast Ranges has been logged concurrently with the predominant Douglas-fir (*Pseudotsuga menziesii*). Logging activities, through movement of contaminated soil, are extensively introducing the fungus into mountain forests, and mortality is appearing in blocks of reserve timber (fig. 3). Acceleration of harvest of the Port-Orford-cedar because of the disease seems imminent (fig. 4).

There appears to be no hope of raising another crop of Port-Orford-cedar under existing conditions of disease and land use. Cedar regenerates profusely from existing seed sources. Even if the fungus is short-lived in killed trees, this continuing supply of new seedlings seems likely to sustain the disease in a chronic state. Probably few trees will survive to merchantable size. Clearly, the loss of values that might have been achieved were it not for the disease is staggering. Log prices in 1969 averaged $360 per thousand board feet and value of total production exceeded $13 million. This total will likely decline and ultimately drop to nearly nothing as the remaining merchantable trees die or are harvested.

Control

There is no known control for this disease nor are there any known conditions of soil or climate in areas suitable for Port-Orford-cedar that may limit the disease. No evidence of genetic resistance has been found in several thousand trees tested, and no-

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Figure 2.—Dead young Port-Orford-cedars along a skid road in a farm wood lot after introduction of *Phytophthora lateralis* during logging of a Douglas-fir overstory. (Photo, courtesy Oregon State University, Corvallis.)

table differences of susceptibility among horticultural varieties have not been reported by nurserymen. Limited tests suggest that Asiatic species of *Chamaecyparis* are somewhat resistant as is Alaska-cedar (*Chamaecyparis nootkatensis*).

The outlook for chemical control is poor. Although soil fumigants can suppress species of *Phytophthora* in nursery soils under intensive management, they cannot eliminate them. Application of chemicals under southwest Oregon forest conditions is currently out of the question.

The infectiousness of the disease seriously limits control through stand management. Present practices are likely to accelerate losses (fig. 4). Ultimately, management may be intensified to allow control by exclusion of the fungus from selected management units. Managers who want to protect Port-Orford-cedar must be willing to accept considerable disarrangement of conventional management and logging plans. If control through management is undertaken, the following should be considered.

Timberlands.—1. Wherever possible, a policy of nonentry of people, animals, and equipment should be followed in stands containing cedar of any age. Where old-growth timber is involved, this will be possible only in a lim-

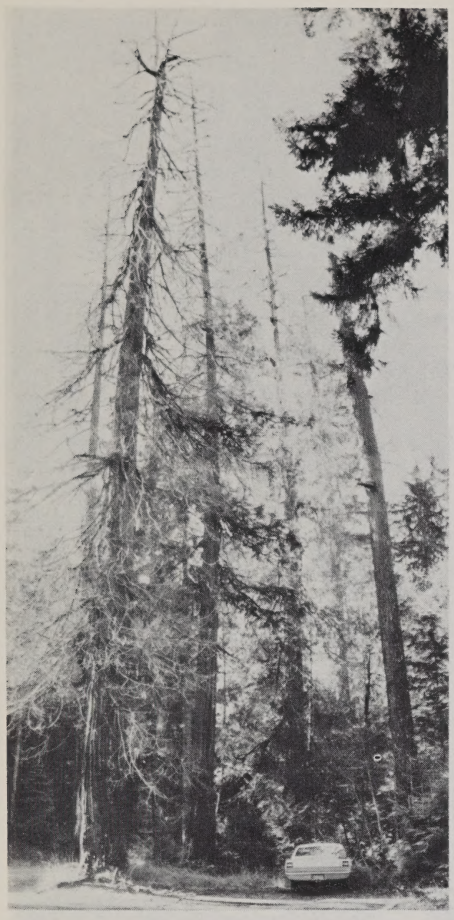

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Figure 3.—Old-growth Port-Orford-cedars killed by *Phytophthora lateralis* along a forest road. Siskiyou National Forest, Curry Co., Oregon, 1970. (Photo, courtesy Oregon State University, Corvallis.)

ited way. Probably entry should be allowed where there are concentrations of infected, salvable young timber; however, entry to salvage widely scattered, diseased young growth should not be allowed.

2. Prelogging of the cedar in an infected old-growth forest (fig. 4) probably is preferable to repeated entry for salvage.

3. When cutting in diseased old growth, remove or destroy all healthy cedars including the smallest seedlings. Removal of the supply of host trees will help make the site uninhabitable for the root rot fungus.

4. Establish lateral edges of cutting units at the limits of flow of surface water from the unit. In young stands, place the limits against marked changes in tree species.

5. Never operate equipment from a contaminated area into a clean one, nor move clean equipment into a contaminated area and return. When salvage logging, always work from the downhill side and remove all cedars. Restrict equipment to the infestation area and to exit roads. All long-established roads should be regarded as containing infested soil.

6. New road construction into thinning units must be with clean equipment, steam cleaned if necessary, and must avoid all spots of infection. Wherever possible, road locations should drain away from cedar values to be protected.

7. Tractor thinning is discouraged, even with cleaned equipment. Cable thinning must not drag logs from or through spots of infection. Practically, trucks probably cannot be cleaned. Landings must therefore drain away from protected stands.

8. Install locked gates to exclude cattle and discourage human entry where possible.

Residential trees.—1. Do not plant Port-Orford-cedars in locations subject to flow of surface water.

2. Avoid all planting including oranmentals and rooted flowers near established trees or uphill from them.

3. Similarly avoid all earth moving construction.

4. Ownership patterns, property lines, and rights-of-way will sometimes make protection impossible.

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Figure 4.—Part of an old-growth forest unit prelogged to remove dead and threatened Port-Orford-cedar. More extensive spread may be expected below the unit than would have occurred by not logging. Cedar residuals (foreground) will perpetuate the fungus in the logged area. Satisfactory alternative procedures are not available. (Photo, courtesy Oregon State University, Corvallis.)

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